NAME _____ DATE _____ CLASS _____

Forces and the Laws of Motion

Problem A

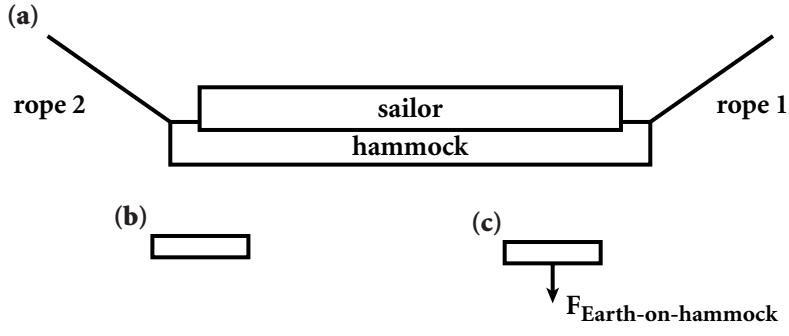
DRAWING FREE-BODY DIAGRAMS

PROBLEM

Before bunks, sailors slept in hammocks strung between beams below deck. Because the hammocks were suspended, they allowed the sailors to maintain a fairly level, horizontal position even though the ship itself might be rising and falling on the swells. Suppose a sailor is resting in a hammock. The gravitational force of Earth on the hammock is 150 N. The downward force that the resting sailor exerts on the hammock is an additional 850 N. The supporting rope at one end of the hammock exerts a force of 780 N at an angle of 50.0° clockwise from the vertical. The rope at the other end exerts a force of 780 N at an angle of 50.0° counterclockwise from the vertical. A very simplified sketch of the situation is shown in (a). Draw a free-body diagram of the hammock.

SOLUTION

1. **Identify the forces acting on the object and the directions of the forces.**
   - Earth exerts a downward force of 150 N on the hammock.
   - The sailor exerts a force 850 N downward on the hammock.
   - Rope 1 exerts a force of 780 N at an angle of 50.0° clockwise from the vertical.
   - Rope 2 exerts a force of 780 N at an angle of 50.0° counterclockwise from the vertical.
2. **Draw a diagram to represent the isolated object.**
   The hammock can be represented by a simple outline, as shown in **(b)**.
3. **Draw and label vector arrows for all external forces acting on on the object.**
   A free-body diagram of the hammock will show all the forces acting on the hammock as if the forces are acting on the center of the hammock. First, draw the downward force that Earth exerts on the hammock as shown in **(c)**. Be sure that the length of the arrow approximately represents the magnitude of the force. Then draw the force that the sailor exerts on the hammock as shown in **(d)**. Continue by drawing and labeling the upward force exerted by Rope 1, as shown in **(e)**. Repeat for Rope 2, as in diagram **(f)**. Diagram **(f)** is the completed free-body diagram of the suspended hammock.



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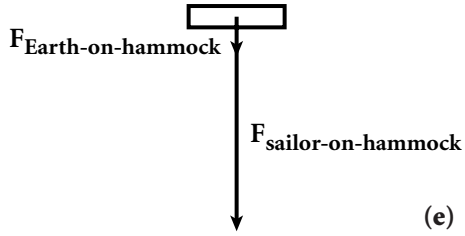
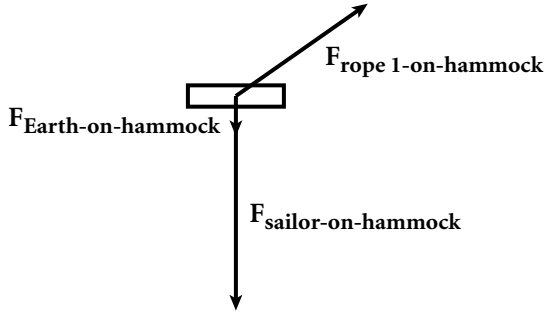
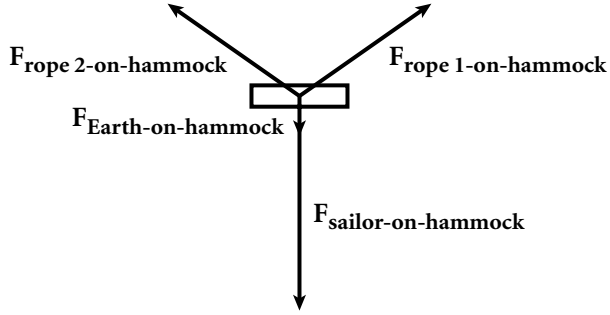
(d)



(e)



(f)



ADDITIONAL PRACTICE

1. Many orangutans spend their entire lives among the trees and are well adapted to move in this arboreal habitat. They have long arms (about two-thirds of their body height) and powerful chest muscles. Suppose an adult orangutan is hanging by its arms from a tree branch. The angle between each of the animal's arms and the vertical is 15° with each arm exerting a force 430 N. The gravitational force acting on it is 830 N. Draw a free-body diagram of the animal.

2. Rock wall climbing is a challenging activity. Suppose that on one ascent, a climbing piton is wedged into a crevice on the rock wall. A climber negotiating the wall exerts a force of 350 N at an angle of 65° below the horizontal on a rope secured to the piton. The rock surrounding the piton exerts an upward force of 320 N and a horizontal force of 150 N to the left on the pin. Draw a free-body diagram of the pin.

3. An experienced pilot can keep an engineless glider aircraft aloft for hours by using only the lift provided by rising air currents. Suppose during a flight an upward force of 5.00×10^3 N is exerted on the glider. Simultaneously, the glider experiences a forward force of 0.50×10^3 N. The gravitational force acting on the glider and its pilot is 4.80×10^3 N. Draw a free-body diagram of the glider.